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U.S. ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

AMSTE-RP-702-101
*TOP 2-2-819
AD No.

31 January 1989

WHEELED AND TRACKED VEHICLE
AIR CLEANER TESTING

	<u>Page</u>
Paragraph 1. SCOPE	1
2. FACILITIES AND INSTRUMENTATION	1
2.1 Facilities	1
2.2 Instrumentation	2
3. REQUIRED TEST CONDITIONS	3
3.1 Facilities and Instrumentation	3
3.2 Environmental Factors	4
3.3 Other Factors	5
4. TEST PROCEDURES	5
4.1 Dust Course	5
4.2 Other Courses	7
5. DATA REQUIRED	7
5.1 Pretest	7
5.2 During Operation	8
5.3 After Each Cycle	8
5.4 Laboratory	9
6. PRESENTATION OF DATA	9
Appendix A. OIL SAMPLE LABORATORY TESTS.....	A-1
B. DATA SHEET.....	B-1
C. REFERENCES.....	C-1

1. SCOPE. This TOP describes a field performance test for air cleaner adequacy of wheeled and tracked vehicles. This test is particularly appropriate for desert environmental testing, as large amounts of dust become airborne with the passage of vehicles due to the low moisture content of the sand, silt, and clay soils that are characteristic of desert areas.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

<u>Item</u>	<u>Requirement</u>
Dust Course	Fairly level, straight, and smooth surface of desert pavement, known as gravelly undissected piedmont, uniformly mixed surface (usually accomplished using a crawler tractor pulling a disk harrow), 10-15 cm deep; low moisture content (depending on time of year), 4% maximum.

*This TOP supersedes TOP 2-2-819 dated 7 December 1979. AD No. A078945
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31 January 1989

TOP 2-2-819

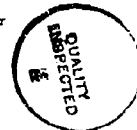
<u>Item</u>	<u>Requirement</u>
Level Cross-Country Course	Unprepared course traversing washes, gravelly dissected piedmont, sandy plains and hills, and moderate grades of short duration.
Gravel Course	Prepared natural surface covered with small-sized gravel; fairly level, with minimum grades of medium duration.

2.2 Instrumentation.

<u>Devices for Measuring</u>	<u>*Permissible Error of Measurement</u>
Time	+0.5 min or +2% of the true value, whichever is larger
Road speed (speedometer)	0-50 km/hr: +0.2 km/hr 0-100 km/hr: +1.0 km/hr 0-200 km/hr: +2.0 km/hr
Engine speed (transducer)	0-3000 r/min: +5 r/min 0-6000 r/min: +10 r/min
Pressure	+4% full range at any value, (normally 152.4 cm water (-14.95 kPa) for air cleaner restrictions)
Engine oil pressure (pressure transducer)	
Weight of air cleaner element	+5%
Meteorological conditions:	
Ambient temperature	+3°C of true value
Relative humidity	+2%
Wind speed	+3 km/hr
Wind direction	+10°
Barometric pressure	+0.4 kPa
Accrued mileage (odometer)	+3 km
Component temperature (temperature transducer)	
Size of airborne dust particles	U.S. Standard Sieves No. 60 through 200 and colter counter

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DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail. and/or Special
A-1	

*The permissible error of measurement for instrumentation is the two-sigma value for normal distribution; so the stated errors should not be exceeded in more than one measurement of 20.



Devices for Measuring (cont'd)Permissible Error

Concentration of airborne dust

(Vacuum pump, flowmeter, and sample bottles filled with filtered water are used to collect dust from the air. Nephelometers are recently developed devices that measure real-time concentration by light scattering techniques when 80% of the airborne dust particles have diameters of 20 micrometers (um) or less. A combination nephelometer/single-particle counter that measures near real-time concentration of particles having diameters from 0-200 um may also be used.)

Permissible error limits are being studied for nephelometers and nephelometer-single particle counters

3. REQUIRED TEST CONDITIONS.

3.1 Facilities and Equipment.

a. Review the developer's environmental documentation for adequacy and comparison with the installation's Environmental Assessment (EA) to ensure that proposed and ongoing actions have been adequately addressed. Prepare any required test project environmental documentation that addresses those test-related environmental issues not covered in sponsor documents or installation documents. Do not begin testing until all environmental documentation has been prepared, applicable public notice and comment period has ended, and the requirements of AR 200-2¹ have been fully met.

b. Ensure that the ground surface has been disked and that the moisture content is low. (See 2.1 above.)

c. Ensure that the following are available for use and in serviceable working condition and/or calibrated:

- (1) Test vehicle operator's breathing apparatus
- (2) U.S. Standard Sieves No. 60 through 200 and colter counter to determine size of particles in dust samples
- (3) Soil sample moisture determination apparatus
- (4) Air cleaner element weighing apparatus
- (5) Compressed air supply pressure regulator and pressure gage

¹Footnote numbers match references in appendix C.

(6) Nozzle or tubing with a maximum inside diameter of 0.3175 cm for use in blowing dust from the air cleaner element

(7) Disk to prepare the surface of the dust course

d. Check the test vehicle to ensure:

(1) The engine is properly tuned.

(2) All drive belts are working.

(3) The coolant thermostat operates correctly.

(4) The idle is set at correct low and high speeds.

(5) The high stall speed is correct.

(6) The proper type and amount of lubricants are present.

(7) All air intake ducting is serviceable.

(8) All air intake ducting is clean beyond the filter element.

(9) All air intake duct clamps are serviceable and tight.

(10) The air cleaner canister is securely mounted and serviceable (including clamps).

(11) The air cleaner canister and filter element may be easily removed without interference from hoses, etc.

(12) The tire pressure or track tension is proper.

(13) All rod end bearings are working on the throttle and transmission shift linkages.

e. Check the new air cleaner elements for visible defects.

f. Make other vehicle checks as required.

3.2 Environmental Factors.

a. Ensure, for repeatable results, that the average wind velocity is within ± 8 km/hr and wind direction is within $\pm 20^\circ$ (or $180^\circ \pm 20^\circ$) of that during previous tests.

b. Stop all testing when any of the following environmental conditions are exceeded:

(1) Maximum wind speed, 20 km/hr

(2) Maximum relative humidity, 60%

(3) Minimum ambient temperature, 14°C

(4) Maximum moisture content of dust, 4 percent

Factors of wind speed, wind direction relative to course direction, relative humidity, ambient temperature, moisture content of the dust, and dust cloud particle concentration must also be considered collectively as to their impact on the test. Engineering judgment must be used to determine if the test conditions are adequate to continue the test.

3.3 Other Factors. Ensure the following:

- a. All equipment checks are satisfactory or corrections made.
- b. All instrumentation is calibrated.
- c. The instrumentation list specifically states the installed location or method.
- d. The vehicle configurations tested are identified.
- e. Those item-particular controls critical for achieving accurate and reproducible test results have been determined.
- f. The operator must know how to use the breather or dust mask.

4. TEST PROCEDURES.4.1 Dust Course.

- a. Install a new, weighed air cleaner element in the vehicle just before starting the test.
- b. Take an engine oil sample.
- c. Take soil samples.
- d. Record the vehicle odometer reading.
- e. Determine the initial air cleaner restriction at maximum air demand, high stall conditions, or high idle speed.
- f. Set the air sampler flow rate. Switch on the nephelometer.
- g. Operate the test vehicle over the dust course at or near an engine speed or maximum air demand either with or without a lead vehicle or both, depending on test requirements and expected vehicle use. (A lead vehicle simulates convoy conditions.)
- h. Monitor the speed of the test vehicle commensurate with safety.
- i. Operate the test vehicle in the densest portion of the dust cloud produced by the lead vehicle, if applicable, commensurate with safety.
- j. Read the pressure transducer, and record the air cleaner restriction at maximum air demand, high stall conditions, or high idle speed as a function of elapsed time.

- k. Make notes pertinent to vehicle operation.
 - l. Continue operations until the air cleaner restriction increases to the recommended maximum, a significant power loss has been observed, or until other specified criteria are attained.
 - m. Turn off the air sampler. Read the dust concentrations recorded on nephelometer, and turn it off.
 - n. Record the required vehicle data. (See 5. below.)
 - o. Take an engine oil sample. See appendix A for specific laboratory tests.
 - p. Remove the air cleaner element, being careful not to loosen any dust from the element. Insert the element into the plastic bag.
 - q. Inspect the air intake for dust beyond the air cleaner seals.
 - r. Save any dust in the air cleaner canister.
 - s. Obtain a sample of exhaust dust (if possible), if the vehicle is equipped with blower motors to exhaust dust from the canister or enclosure.
 - t. Change the air sample bottles.
 - u. Record the required air cleaner element data.
 - v. Take a sample of dust from the exterior of the air cleaner element.
 - w. Clean the air cleaner element according to the instructions contained in the technical manual, using the on-vehicle equipment specified. Do not substitute shop equipment for on-vehicle equipment. If the technical manuals do not prescribe a procedure, request one from the materiel developer. If a procedure cannot be obtained due to the developmental nature of the item, proceed as follows:
 - (1) Remove the air cleaner, and rap it against the palm of the hand to dislodge the larger particles. Continue this until visible evidence of particle dropping has ceased.
 - (2) Using a compressed air source of not more than 690 kPa (100 psi), blow the dust from the air cleaner using a nozzle not larger than 0.3175 cm. Do not hold the nozzle in direct contact with the element. Direct the air first against the inside of the element, then against the outside of the element.
- NOTE: The cleaning time should not exceed the time allotted for crew services and checks specified in the requirements documents. If no such times are specified, do not exceed 20 to 30 min for vehicles with single air cleaner elements.
- x. Check the air cleaner element for damage.

- y. Record operational or functional problems caused by dust.
- z. Reinstall the element, and start the test cycle (steps b. through v. above) until a stabilized operating time (from recleaning to maximum restriction) is attained or approached.

4.2. Other Courses (less airborne dust generated other than on the dust course).

a. Perform this subtest on the level cross-country course or the gravel course (whichever is more appropriate according to test requirements and expected vehicle use), if time allows.

b. Perform with or without a lead vehicle or both, depending on test requirements and expected vehicle use.

c. Operate at normal vehicle speed for the course selected and not necessarily at maximum air demand.

d. Ensure, when using a lead vehicle, that the test vehicle follows the path of the lead vehicle (not the dust cloud of the lead vehicle), at a distance commensurate with safety considerations.

e. Start the initial cycle with a new air cleaner element and a recleaned element on subsequent cycles.

f. Determine the initial restriction at high stall or high idle speed.

g. Record the air cleaner restriction as a function of elapsed time.

h. Continue testing following the method in 4.1 above, steps g. through q.

i. Reinstall the cleaned air cleaner element, and repeat the test cycle (steps c. through h. immediately above) until a stabilized operating time (from recleaning to maximum restriction) is attained or approached.

5. DATA REQUIRED. See data sheet, appendix B.

5.1 Pretest. Record the following:

- a. Results of equipment checks and calibrations. (See 3.1 above.)
- b. Vehicle test configuration
- c. Instrumentation calibration and accuracy
- d. Test course soil moisture content
- e. Initial weights of new air cleaner elements
- f. Initial weights of new plastic bags used to transport air cleaner elements which have reached maximum restriction

g. Manufacturer's or technical manual's recommended maximum value for air cleaner restriction or other specified limiting conditions

h. Initial air cleaner restriction during operation

i. Air cleaner restriction at high stall, high speed idle, or maximum air demand, and the corresponding engine speed

j. Odometer reading

k. Meteorological data

l. Course used

m. Whether a lead vehicle was used

n. Normal operation or maximum air demand

o. Flow rate of air sampler

5.2 During Operation. During test operations, record the following:

a. Air cleaner restriction as a function of elapsed time

b. Notes on vehicle operation or problems as appropriate (temperatures, linkage)

c. Meteorological data

5.3 After Each Cycle. After each cycle, record the following:

a. Vehicle data:

(1) Elapsed operating time of vehicle and air sample

(2) Final restriction across the cleaner

(3) Engine speed and final restriction

(4) Reason for cycle termination

(5) Odometer reading

(6) Weight of dust in air cleaner canister

(7) Evidence of leakage of dust past the air cleaner

(8) Potential problem areas caused by dust accumulation

b. Soil moisture content

c. Air cleaner element data:

(1) Weight of element after test cycle

- (2) Cleaning method
- (3) Cleaning time
- (4) Weight of element after cleaning
- (5) Evidence of damage to filter

5.4 Laboratory. In the laboratory, document the following:

- a. An analysis of pretest and posttest engine oil samples for each cycle (appendix A)
- b. For each cycle, a particle size analysis of the dust from:
 - (1) Air cleaner element exterior
 - (2) Air cleaner canister
 - (3) Canister blower exhaust
 - (4) Air intake ducting beyond the air cleaner
 - (5) Air sampling apparatus
- c. The average dust concentration in the air at sampling locations for each cycle
- d. The moisture content of soil samples before and after each cycle

6. PRESENTATION OF DATA.

- a. The air cleaner restriction versus elapsed operating time for each cycle will be presented in graphic format.
- b. Present the following in tabular format:
 - (1) Results of preliminary equipment checks
 - (2) Laboratory analysis of all air, soil, dust, and engine oil samples
 - (3) Meteorological data
 - (4) Air cleaner element data (operating time, weights, inspection for damage, miles accrued, average speed per cycle, cleaning time, final restriction, and engine speed)
- c. Present the following in narrative format:
 - (1) Potential problem areas due to dust accumulation

31 January 1989

TOP 2-2-819

- (2) Functional problems caused by dust contamination
- (3) Test procedure, course used, and vehicle configuration
- (4) Summary of results

Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to Commander, U.S. Army Test and Evaluation Command, ATTN: AMSTE-TC-M, Aberdeen Proving Ground, MD 21005-5055. Technical information may be obtained from the preparing activity: Commander, U.S. Army Yuma Proving Ground, ATTN: STEYP-MT-I, Yuma, AZ 85365-9103. Additional copies are available from the Defense Technical Information Center, Cameron Station, Alexandria, VA 22304-6145. This document is identified by the accession number (AD No.) printed on the first page.

31 January 1989

TOP 2-2-819

APPENDIX A

OIL SAMPLE LABORATORY TESTS

	<u>ENGINE</u>	<u>TRANSMISSION</u>
COMPONENT TYPE	:	
DATE SAMPLED	:	
YEAR-SAMPLE NUMBER	:	
DATE RECEIVED	:	
COMMENTS	:	
TEST MILES	:	
TEST HOURS	:	
OIL QUALIFICATION NUMBER:		
A.P.I. GRAVITY	DEGREES:	
FLASH POINT	°C:	
CARBON RESIDUE	%:	
SULFATED ASH	%:	
VIS AT 40°C	CS:	
VIS AT 100°C	CS:	
VISCOSITY INDEX	:	
FUEL DILUTION	%:	
WATER	%:	
ALUMINUM	Al	PPM:
BARIUM	Ba	PPM:
BORON	B	PPM:
CADMIUM	Cd	PPM:
CALCIUM	Ca	PPM:
CHROMIUM	Cr	PPM:
COPPER	Cu	PPM:
IRON	Fe	PPM:
LEAD	Pb	PPM:
MAGNESIUM	Mg	PPM:
MOLYBDENUM	Mo	PPM:
NICKEL	Ni	PPM:
SILICON	Si	PPM:
SILVER	Ag	PPM:
SODIUM	Na	PPM:
TIN	Sn	PPM:
TITANIUM	Ti	PPM:
ZINC	Zn	PPM:
BERYLLIUM	Be	PPM:
MANGANESE	Mn	PPM:
VANADIUM	V	PPM:
REMARKS	:	

(TYPICAL SAMPLE DATA SHEET)

APPENDIX B

[illegible]

(TYPICAL DATA SHEET)

31 January 1989

TOP 2-2-819

APPENDIX C

REFERENCES

1. AR 200-2, Environmental Quality, Environmental Effects of Army Actions, 15 October 1982; suppl 16 August 1983.